WEST AFRICAN COCOA RESEARCH INSTITUTE

# QUARTERLY PROGRESS REPORT

No. 45

TAFO, ~~GOLD COAST.~~ GHANA

COMMONWEALTH MYCOLOGICAL INSTITUTE
7 JUN 1957

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# WEST AFRICAN COCOA RESEARCH INSTITUTE

## T A F O

## FORTY-FIFTH QUARTERLY REPORT : JANUARY-MARCH, 1957

### SENIOR STAFF

| | |
|---|---|
| Director | J. Lamb (returned from leave 3rd March) |
| Deputy Director | C.G. Johnson |
| Scientific Assistant to Director | G.A. Jones (arrived 22nd January) |
| Secretary | H.L. Pugh |
| Director's Secretary/ Librarian | Audrey Bryan |

### TAFO STATION

| | |
|---|---|
| Division of Entomology | D.J. Taylor<br>P.F. Entwistle<br>Helen M. Entwistle |
| Division of Pathology | W.T. Dale (on leave 27th March, prior to resignation)<br>A.L. Wharton<br>G. Usher (on leave, prior to resignation)<br>A. Attafuah |
| Division of Botany | A.D. McKelvie (on leave)<br>D.R. Glendinning<br>R.G. Hurd |
| Division of Chemistry | T.A. Rohan<br>E. Margaret Holden<br>P.W. Arnold<br>R.K. Cunningham |
| Division of Agronomy | R.J. Benstead |
| Plantations Manager | H.W.S. Allison |
| Guide Demonstrator | F.E. Decker |
| Station Manager | S.E. Ntim Kwafo |

### IBADAN SUB-STATION

| | |
|---|---|
| Entomologist (Acting Officer-in-Charge) | R.G. Donald (returned from leave 17th January) |
| Pathologist | J.M. Thresh |

INDEPENDENCE CELEBRATIONS

On 6th March the people of Ghana celebrated their attainment of independence. At W.A.C.R.I. members of the staff took part in a full programme of festivities, culminating in a display of tribal drumming and dancing. The ceremonies included the planting of two cocoa trees at the Community Centre to commemorate the occasion.

MANAGING COMMITTEE

The twenty-first meeting of the Managing Committee was held at Tafo on 28th March. The Technical Sub-Committee met on the preceding day.

STAFF MATTERS

Dr. C.G. Johnson (Deputy Director) acted as Director until Mr. J. Lamb (Director) returned from leave on 3rd March. Mr. G.A. Jones arrived in January to take up his appointment as Scientific Assistant to the Director. Mr. W.T. Dale, who has been head of the Pathology Division since 1953, and Mr. G. Usher have resigned.

Mr. R.G. Donald returned from leave on 16th January, and called at Tafo before proceeding to Ibadan. Mr. R.J. Benstead returned to Tafo on 5th March, handing over the duties of Officer-in-Charge of the Sub-Station to Mr. Donald. Mr. J.M. Thresh spent a few days at Tafo in March.

VISITORS

His Excellency the Governor-General, accompanied by Mrs. Jennifer Williamson, and Mr. G.M. Levack, Acting Regional Officer (Eastern Region), with Mr. S.J.E. Southgate, Chairman of the Managing Committee, paid a farewell visit to the Institute on 30th March. A tour of the Station was arranged for delegations to the Independence Celebrations from Russia, West Germany, Holland, Yugoslavia and Ceylon. Other visitors have included the Honourable J.W. Cooper and the Honourable J.P. McRae from Liberia; Mr. J. Cadbury and Mr. D.H. Urquhart of Messrs. Cadbury Bros; Mr. Woodman of the United States Information Services Film

Unit; Mr. Raymond Baxter, Mr. W. Clarke and Mr. Phillips of the British Broadcasting Corporation; Mr. Rose of Micron Sprayers Limited, and Mr. Stapely of Plant Protection Limited.

Visitors to the Ibadan Sub-Station have included Sir Eric Ashby, Principal of Queen's College, Belfast, Mr. Ford Milam of the United States Consular Service and Mr. D. Rhind, Secretary for Agricultural Research, Colonial Office.

## MANAGEMENT AND MAINTENANCE

Work started during the quarter on clearing the sites for six new bungalows in the Residential Area at Tafo. Two bungalows were re-decorated, and minor repairs were carried out in W.A.C.R.I. village and in the laboratories.

The average daily production and consumption of water at the Tafo Station were as follows:

| | Production | Consumption |
|---|---|---|
| January | 28,363 gallons | 24,300 gallons |
| February | 32,313 gallons | 23,393 gallons |
| March | 32,279 gallons | 26,319 gallons |

## CROP DELIVERY

The main crop harvest was completed by 18th January. The percentage of pods discarded showed the usual rise in the final picking associated with the branch crop. Final records for the Uniformity Trial Area, Old Station showed an increase in yield of 30% over that for the previous season.

On all recorded areas the condition of the cocoa has improved considerably with the attainment of efficient capsid control, and shade reduction has also had a beneficial effect.

Many of the shade trees treated with a mixture of 2,4-D and 2,4,5-T have recovered and a start has been made on retreatment using the same dosage, but frilling the trunks prior to application. It has been noted that leguminous trees are particularly susceptible and laticiferous species, or those with a gummy exudate, are the most difficult to kill.

SWOLLEN SHOOT DISEASE

The number of trees removed from the Uniformity Trial Areas during the quarter, due to virus infection and other causes, is shown in the following table. On the Square Mile large-scale clearance work has started, and results of 'Cutting-out' operations have not therefore been included.

| Month | Trees destroyed | | | Infected seedlings removed |
|---|---|---|---|---|
| | Swollen Shoot | Undiagnosed | Total | |
| January | 50 | 10 | 60 | 12 |
| February | 41 | 17 | 58 | 23 |
| March | 32 | 13 | 45 | 22 |
| TOTAL | 123 | 40 | 163 | 57 |

UPPER AMAZON SEED

A further 2,450 F3 pods were despatched to Nigeria during the quarter.

METEOROLOGY

| | 1957 | | 19-year mean | |
|---|---|---|---|---|
| | Rainfall (in.) | Wet days | Rainfall (in.) | Wet days |
| January | 1.28 | 5 | 1.52 | 3.6 |
| February | 2.81 | 6 | 3.62 | 7.0 |
| March | 1.48 | 9 | 5.85 | 11.7 |
| TOTAL | 5.57 | 20 | 10.99 | 22.3 |

# T A F O  S T A T I O N

## PATHOLOGY DIVISION

### VIRUS RESEARCH

#### Host range of cacao-virus isolates

Further observations are being made on the persistence of cacao-virus isolates in alternative hosts. Bosumtwe virus was recovered from Herrania balaensis Preuss., without recourse to coppicing, 36 months after infection, virulent New Juaben virus from Sterculia alata after 25 months, Kpeve from Bombax buonopozense P. Beauv. after 19, and Bosomuoso (2) from Theobroma angustifolia DC. after 11 months. Heliocarpus popayanensis H.B.K. readily yielded Kpeve after 18 months, but virulent New Juaben, Bosomuoso (2) and Offa Igbo (Nigeria) were not recovered from it after comparable periods.

Material from about 200 more baobab trees (Adansonia digitata L.), all in Trans-Volta/Togoland or the eastern part of the Northern Territories, has been collected, and is being tested for the presence of viruses transmissible to cacao. Many other trees were examined, samples being usually taken only from those of great age or showing features considered indicative of possible virus infection. Cacao-bean indicator plants have already been infected from a tree at Agboleve, a few miles east of Kpeve. Very suspicious material has also been collected at Ho and at Mile 102 on the Accra-Denu road, where baobabs are particularly common. Present indications are that virus infection in these trees is commoner in the south of Ghana than in the extreme north, suggesting that they may have become infected from some other host, perhaps a highly tolerant indigenous one.

#### Transmission studies

Ferrisiana virgata (Ckll.) has experimentally transmitted the Sedi Nkawie and Ankrankwanta cacao-virus isolates from Ashanti, and Pseudococcus njalensis Laing that from Worawora in Togoland (cf. Quarterly Report No. 43).

#### Classification and comparison of isolates

Further material has been collected from cacao trees showing unusual virus symptoms, so that the isolates concerned may be studied in the laboratory. Most of these recent collections are from discrete outbreaks selected for the joint W.A.C.R.I. - Department of Agriculture experiments on swollen-shoot disease control. New Juaben is spreading into areas where other

distinct isolates occur. This has happened at Mamfe to the south (loc. cit.), where some trees were found to be infected by both Mampong and virulent New Juaben. To the north, outbreaks of the latter are interspersed with others showing characteristic leaf symptoms and, in some instances, lacking swellings. Mild viruses of this type are known from the vicinity of Osino, and may also occur around Kwabeng and at Fankyeneko near Bosuso. Avirulent infections are also present in the Nkawkaw area, but there is as yet no reason to think that these differ appreciably from the isolate already described from there (Posnette, Ann. appl. Biol., 34, p.388, 1947). When the Worawora isolate was transmitted to dissected beans (see above), swellings appeared on the young plants in less than three months, becoming large and numerous. The symptoms resemble those of Bisa (Manya Krobo), though the slight or transient leaf symptoms sometimes produced by that isolate have not yet been observed.

In Quarterly Report No. 43 it was reported that five basket seedlings were 'challenged' with a virulent strain of New Juaben after being infected with a mild one for 14 months. In fact, the plants were 27 months old and had been infected with the mild strain in the bean stage. Up to the time of 'challenging' none had given evidence of the presence of virulent strains by symptoms or in 'back-tests', but four months later two began to show more severe symptoms and have yielded both mild and virulent strains in 'back-tests' with single mealybugs. Observations are continuing, but the experiment has already substantiated the claim made in Ann. Rep. WACRI, 1955-56, p.31, that mild-strain protection can break down even in uncoppiced seedlings.

In further tests aimed at revealing immunological relationship (or lack of it) between isolates, Asalu (Nigeria) gave no protection against Kpeve, virulent New Juaben, Nsaba (Eastern Province) or the baobab isolate from Wusuta. Similarly, there was no evidence of interference by mild New Juaben with the subsequent establishment of Nkawkaw, two baobab isolates (AD7 and 14) or two additional ones from Cola chlamydantha (Achechere and Bakukrom).

Resistance and tolerance

All six Iquitos-type 'twinned' plants that developed only transient symptoms of New Juaben (Quarterly Report No. 44) have now given evidence of persistent infection following coppicing. The two that had not done so up to the end of last

quarter have still not shown symptoms on their regenerating growth, but some of the cuttings taken from each have shown symptoms, without yet giving positive 'back-test' results. The remaining four plants have produced symptoms on their regenerating growth, but some of the cuttings from two of them have yet to give any evidence of infection. This provides further evidence that some highly tolerant plants with symptomless phases contain too little available virus for mealybugs to have a reasonable chance of transmitting it. In some instances the available virus may be localized, so that coppiced plants or some of the cuttings derived from them may be virus-free. Patch-budding with Amelonado should show if this is really so, besides providing a check on whether material is indeed highly tolerant or has merely, by chance, become infected with a mild strain of the virus.

The experiment to compare resistance and tolerance to virulent New Juaben in F1 Iquitos-type (T17) seedling trees (Quarterly Report No. 38, et seq.) is almost complete. T17/1159, 359, 448, 2655, 434, 1131, 1157, 2628 and 1071 seem most promising as regards resistance, though the level of this must be low. Cuttings in all four replicates have been scored for tolerance as described in Ann. Rep. WACRI, 1955-56, p.36, and mean scores have been calculated for each clone. T17/524 was the most consistently tolerant, with a score of 2.85; next came 1071 (2.37, but incomplete), 2652 (2.07), 448 and 1220 (2.00 each). There is little to suggest that resistance and tolerance are closely correlated.

Uninfested twinned seedlings (loc.cit.) corresponding to infested ones which remained apparently virus-free or showed varying degrees of tolerance have been used to provide rooted cuttings for further testing. Many of the tests have already been done, using 20 nymphs of P. njalensis per plant, but 'back-tests' on symptomless cuttings are not yet available. It is hoped to ascertain how far the five plants which gave no evidence of infection in the initial test are genuinely more resistant. At least one cutting each from four of them has already shown symptoms. The experiment may also provide more information on the association (or lack of it) between resistance and tolerance, and the extent to which the former (like the latter) is subject to genetical segregation within the T17 progenies.

Cuttings in the first replicate of the similar experiment to compare resistance and tolerance of the same F1 T17 stands to Kpeve (Quarterly Reports No. 42 and 44) have been scored for tolerance, using a somewhat similar system to that employed for New Juaben. Unless low availability of virus to vectors is a major factor, the material is more resistant to Kpeve than it is to New Juaben. It is certainly far more tolerant to the former.

Attempted mechanical transmission

Seedlings of Gomphrena globosa and Corchorus olitorius have been used as test plants for the Kpeve and New Juaben strains using infected cacao seedlings as the source of inoculum. Extracts from Corchorus plants infected with New Juaben were also used for inoculation to Corchorus. Very young seedlings of Adansonia digitata were used as test plants for extracts prepared from cacao and Adansonia seedlings infected with an isolate (Wusuta) from Adansonia and from cacao seedlings infected with New Juaben. All extracts were made by grinding leaves in citrate buffer containing cysteine hydrochloride and were rubbed on to the leaves of test plants using hyflosupercel or carborundum as an abrasive. No obvious symptoms have appeared but 'back-tests' to cacao using mealybugs are being made from some of the inoculated plants.

Chemotherapy

It was reported in Quarterly Report No. 44 that thiouracil appeared to delay the appearance of virus symptoms when applied to cacao plants infected as seedlings and to have no delaying action when the plants were infected in the bean stage. This difference has not been found in subsequent experiments. It has been confirmed that treatment with thiouracil of germinating beans, infected with New Juaben virus, does not affect the rate of appearance of symptoms compared with untreated controls. Measurements of height and weight were made and the number of distorted leaves recorded. The figures confirmed the visual impression that symptoms of infection were worse in the thiouracil treated seedlings than in infected controls although the thiouracil treatment (250 ml. of a 50 mg./l. solution, daily, to 30 seedlings) had no visible effect on healthy controls.

A similar experiment using the Kpeve strain has had to be abandoned because of irregular germination of the beans.

It has not, however, been confirmed that thiouracil treatment of plants infected as seedlings delayed the appearance

of symptoms. In different experiments different numbers of mealybugs had been used for doing the transmissions and it seemed possible that this factor might be involved in the discrepant results obtained. An experiment has been started in which from one to 16 mealybugs per plant were used and the rate of appearance of symptoms in thiouracil treated and untreated plants will be recorded.

The effect of 8-azaguanine has been tested on plants infected both as beans or as seedlings. It was used as a 50 mg./l. solution in 0.01% sodium bicarbonate solution, the higher concentrations of bicarbonate usually used being toxic to cacao seedlings. No delay in the appearance of symptoms has been observed in any of these experiments. Like thiouracil azaguanine causes infected plants to be more stunted and distorted than similar untreated ones.

## STUDIES ON BLACK-POD DISEASE

### Fungicidal control trials

Records for Trial I during the 1956-57 season are complete and the experiment has now been terminated. As relatively few pods were harvested in the quarter, figures for the whole season are given in the table on Page 10 for comparison with the 1955-56 results shown in Quarterly Report No. 41.

An additional treatment (F2 in the table) was included this year to see the effects of frequent spraying during the period when black pod disease normally builds up to a peak. The results generally confirm those for the previous year and it is not necessary to reiterate the comments already made (*loc. cit.*). Spraying has reduced losses from black pod disease to very low levels but as a result of this reduction in foci of infection there has been a marked drop in disease incidence in unsprayed control plots. The F2 frequency of spraying treatment has proved little more effective than regular monthly spraying.

### Cushion infection

Estimates of cushion infection from the first 'pod-painting' experiment (Quarterly Report No. 40 and *Ann. Rep.* WACRI, 1955-56) were obtained by assessing the expected numbers of 'black pods' on the treatment trees if pods had not been brush-painted with a fungicidal paste. This assessment was based on two years pretreatment records for the treated trees and those in the nearby unsprayed control plots of Trial I. An additional year's post-treatment records have now been taken on

## POD YIELDS - TRIAL 1 - 1956/57

| Fungicide | Frequency of application | Frequency of harvesting | Mean yield | Damaged % * | 'Black' pods' % * | Rodent damaged % * | Otherwise damaged % * |
|---|---|---|---|---|---|---|---|
| Unsprayed (Control) | - | Weekly | 79.7 | 28.7 | 10.0 | 12.4 | 6.3 |
| | | Monthly | 58.9 | 40.9 | 17.8 | 17.3 | 5.8 |
| Carbide Bordeaux Mixture | F1 | Weekly | 53.3 | 27.8 | 1.7 | 18.6 | 7.5 |
| | | Monthly | 41.0 | 21.4 | 4.1 | 14.6 | 2.7 |
| | F2 | Weekly | 74.7 | 17.4 | 3.3 | 10.2 | 3.9 |
| | | Monthly | 48.9 | 30.9 | 4.9 | 22.7 | 3.3 |
| | F3 | Weekly | 84.6 | 22.3 | 3.1 | 14.2 | 5.0 |
| | | Monthly | 59.3 | 25.2 | 5.7 | 16.0 | 3.5 |
| Ordinary Bordeaux Mixture | F1 | Weekly | 75.0 | 16.4 | 4.1 | 8.4 | 3.9 |
| | | Monthly | 74.8 | 38.6 | 6.7 | 27.4 | 4.5 |
| | F2 | Weekly | 52.3 | 27.1 | 5.7 | 15.3 | 6.1 |
| | | Monthly | 68.4 | 31.3 | 8.8 | 18.1 | 4.4 |
| | F3 | Weekly | 67.6 | 19.6 | 6.4 | 8.9 | 4.3 |
| | | Monthly | 49.8 | 35.3 | 7.2 | 19.7 | 8.4 |
| Perenox | F1 | Weekly | 85.5 | 19.5 | 2.1 | 13.1 | 4.3 |
| | | Monthly | 60.0 | 31.3 | 5.0 | 22.3 | 4.0 |
| | F2 | Weekly | 61.6 | 22.2 | 5.2 | 12.5 | 4.5 |
| | | Monthly | 43.7 | 26.6 | 7.1 | 15.6 | 3.9 |
| | F3 | Weekly | 59.4 | 25.6 | 5.4 | 15.3 | 4.9 |
| | | Monthly | 57.0 | 26.2 | 7.2 | 15.8 | 3.2 |

* Classified pods as a percentage of mean yield.

F1 24 applications per annum - weekly, fortnightly or monthly depending on the seasonal incidence of black pod disease.

F2 8 fortnightly applications from May to August.

F3 12 monthly applications.

the trees originally treated and these have confirmed the accuracy of the assessment, and hence the estimates of pod infection arising from the cushions.

Effect of age and size of pod on susceptibility

Of the 401 'black pods' recorded during the year 106, 172 and 123 were respectively fruits less than 10 cm. in length (cherelles), green pods above 10 cm. in length, and ripe pods which had been left on the trees for a period of up to six weeks after ripening. The interesting figures are those for cherelles and ripe pods. The latter again illustrate the benefits to be gained from regular frequent harvesting during the main crop season, the figure of 123 diseased ripe pods representing a potential crop loss of over 10 per cent. Cherelle infections are much higher than was previously realized. The figures could be obtained only by inspecting the trees every two days, thus allowing infected cherelles to be distinguished from those affected by wilt. In future recording of cacao selections for resistance or tolerance to pod diseases it will be important to detect these infections as far as possible on young fruits.

Strains of Phytophthora palmivora Butl. occurring in Nigeria and Ghana

Extensive collections of isolates will be made in Ghana and Nigeria during the early rains of the next quarter. Of the few so far examined the only differences recorded are between isolates from the two territories. The most marked difference has been in the growth of the fungi in oatmeal agar culture, the mean rate of growth per day for Nigerian isolates being 1.8 to 2.0 mm. and for those from Ghana 17.9 to 22.7 mm.

Pod inoculation techniques

Work has started on the development of a standard technique for inoculating unwounded cacao pods with P. palmivora.

## ENTOMOLOGY DIVISION

### CAPSID STUDIES

Population studies

The experiment, first started in January 1956, to investigate the possibilities of capsid population estimation by egg counts, was discontinued in December 1956.

Significant correlations were obtained between post-eclosion populations and counts of unhatched eggs made in the previous sampling period. Rather more important is the fact that when data were transformed to weighted fortnightly running

means (one fortnight being the sampling interval) a significant correlation could be obtained between eggs and capsids of the same fortnight. It was not possible, however, to go beyond this and prognosticate population rises from egg counts. Even had this been feasible the problem of forecasting a specific degree of population change rather than a purely relative one would have been complex, requiring, in the area of cacao used, an accurate estimate of available oviposition sites to which the sample removed could be related.

Taken simply as a means of absolute population estimation, egg counts are of less value than counts of post-eclosion stages, due to this difficulty of estimating available oviposition sites.

Vertical distribution of capsid eggs

Some further data are available concerning the effect on egg distribution in mature trees of increased spacing, where more light is incident at lower canopy levels. Two spacings are compared in the tables below:

4' x 4' Spacing.

| Height intervals | 0-5' | 5-10' | 10-15' | 15-20' | 20-25' |
|---|---|---|---|---|---|
| Trees 15-20' | 3.09 | 6.21 | 8.81 | 20.47 | - |
| Trees 20-25' | 0.0 | 2.34 | 9.90 | 12.70 | 18.30 |

8' x 5½' Spacing.

| Height Intervals | 0-5' | 5-10' | 10-15' | 15-20' | 20-25' |
|---|---|---|---|---|---|
| Trees 20-25' | 0.0 | 9.34 | 13.44 | 2.97 | 3.40 |

The data in both tables are in terms of eggs per 100' of damaged tissue. It should be mentioned here that eggs are only found in tissue that has been damaged by capsid feeding and that the distribution of this type of tissue over the tree follows closely that of the bulk tissue distribution. It is clear that with increased spacing the greater part of oviposition occurs at lower to mid-canopy levels, whereas the bulk of the eggs are found in the upper canopy in trees with a closer spacing.

Comparative figures for trees in the 15-20' height category at 8' x 5½' spacing are not yet available.

Joint W.A.C.R.I. & Department of Agriculture insecticides trial

This trial, which was started in August 1956 (Quarterly Report No. 43), has covered the period of peak capsid population and high incidence of damage, and has now been concluded. The insecticides tested were aldrin, dieldrin, endrin, gamma-BHC, and heptachlor. The treatment consisted of two mistblown applications of 2 oz. toxicant per acre in five gallons aqueous emulsion, with an eight week interval. Assessment of new capsid damage was made six weeks after the second application and was repeated thereafter at fortnightly intervals.

With the exception of the heptachlor treatments, very good control of capsids was achieved, and subsequent regeneration of damaged trees was observed in the plots treated with the four other insecticides. Aldrin, dieldrin and gamma-BHC were equally effective, all giving good control. Endrin was outstandingly effective. Heptachlor did not give adequate control.

The relative costs of the four effective insecticides are as follows:-

| | Formulation used | Cost per Imperial gallon (F.O.B. European port) | lb. active ingredient per Imperial gallon | Cost of 1 lb. active ingredient |
|---|---|---|---|---|
| Aldrin | 40% Emulsifiable Concentrate. | 44/- | 4 | 11/- |
| Dieldrin | 20% E.C. | 40/6 | 2 | 20/3 |
| gamma-BHC | 20% E.C. | 56/- | 2 | 28/- |
| Endrin | 20% E.C. | 65/- | 2 | 32/6 |

Thus from the results of this trial it appears that aldrin is the most useful insecticide, considering both its efficiency and relative cost. As the cost of the insecticide forms the greater part of the total cost of the capsid control measures, the use of this newer insecticide would effect a very great financial saving in future operations.

MEALYBUG STUDIES

Mealybug population estimates

Oyoko. Six weeks after spraying with dieldrin counts of *Pseudococcus njalensis* Laing had fallen to zero and at sixteen

weeks showed little sign of increase. Counts of species of mealybug other than P. njalensis have not changed so strikingly, though a definite downward trend is apparent. In view of the much closer association of P. njalensis with ants than is found in other species, this is not surprising. During the period in which counts have been made mealybug populations in the control area have remained relatively steady.

Isolated outbreaks. The first dieldrin application was made towards the end of December 1956 and a second treatment effected seven to eight weeks later. Four of the outbreaks have been selected for malathion treatment, which will be applied at the end of March 1957.

Twelve weeks after the first application counts of P. njalensis showed a 98.5% reduction on pre-treatment population levels. This is a mean figure for all eight sites. There was, however, no discernible change in populations of vector species other than P. njalensis.

Square Mile. Due to the inadequacy of counts to hand height as a completely reliable guide to mealybug population levels on mature trees it was decided to set up a more statistically sound experiment in which complete trees could be employed.

A 40 acre block, C Block in the Square Mile, was set aside as the treatment area, and ten acres of the adjacent B Block as control. Counts are being made of mealybugs on complete felled trees in 16 sub-plots, four of which are allocated to the control, and the remainder to the treated area. During each fortnight five trees are sampled in every sub-plot, each of which has been allocated randomly to one of 16 half-working days. Thus a total of 60 trees in the treated area and 20 in the control area are felled for examination each fortnight.

Pre-treatment counts were made, and the first dieldrin spray applied in the second week in February 1957. Figures are available up to the third fortnightly count after spraying and show a decrease in populations of P. njalensis to approximately 10% of pre-treatment figures.

Very little data are available on population levels of other vector species as these, even in the pre-treatment counts, were unusually scarce.

Parasitism

All adult specimens of P. njalensis found during the routine counts were retained for estimates of parasitism.

In all cases, as P. njalensis populations fell following spraying those of their parasites rose sharply to a peak, naturally falling away again as their hosts became really scarce. Usually the increase in parasitism was of the order of 18 to 20%, i.e. from a 1 or 2% level in pre-treatment counts, to an 18 or 20% level after spraying.

Undoubtedly, as ant protection decreased and mealybugs became exposed, either due to tent deterioration or to their moving from the tents, natural parasites played a part in control. But by far the greatest factor seems to have been that of fungus infection, probably commenced in unconsumed honeydew secretions. Within a short time of spraying many colonies, and isolated individuals, of dead mealybugs were found infected in this way.

Records of parasitism in species other than P. njalensis are not available, as insufficient specimens were encountered in the routine collections.

Formicidal trials

In the preliminary trials which showed that the ant population could be greatly reduced by dieldrin sprays (Quarterly Report No. 44) regular weekly ant surveys have been continued to observe the pattern of reinfestation and population build-up. The most striking feature has been that neither of the two main groups of mealybug attending ants - the Crematogasterini and the Pheidolini - have effectively re-established themselves even after 28 - 30 weeks. At the initial ant survey in a plot at Asiakwa there were 30 trees with Crematogasterine nests; at the last survey, 28 weeks after the dieldrin application, there was only one. In addition to these trees with nests there were 90 trees in the plot on which organised ant activity (i.e. definite columns moving up or down the trunk, or a group attending a mealybug colony) was recorded; at the 28th weekly survey after spraying only eleven trees with such activity were noted. A similar picture has been obtained with the Pheidolini ants. At the initial survey 14 trees with nests, and 16 additional trees with organised activity were seen. At the 28th weekly survey no nests were found in the plot and only four trees were recorded on which organised activity of Pheidole spp. was seen.

Oecophylla longinoda, the dominant ant of cacao, and Macromischoides aculeatus, on the other hand became well established some 18 weeks after the dieldrin application. Both

these species are inimical to the mealybug attending ants.

The difference in establishment is probably associated with the different nesting habits of the various species. The Crematogasterine ants build nests, from vegetable detritus, in close association with the tree trunk whereas both Oecophylla and Macromischoides construct nest with or on leaves in the canopy. Pheidole spp. nest in crevices in trunks of mature trees and in the ground, often at the base of a cacao tree. As was noted in the previous report the greater part of the insecticide in this formicidal spraying is applied to the lower 8 to 10 feet of the trunks of the trees.

Ant surveys were carried out in a field trial which was set up primarily to compare five insecticides, aldrin, dieldrin, endrin, gamma-BHC, and heptachlor, for capsid control (see p.13). There was a slight reduction in the ant population immediately after spraying with all the insecticides. However, the decrease was only temporary and was insignificant when compared with reduction in ant population obtained by trunk applications at the heavier dosage rate of the formicidal spraying mentioned in the previous section.

A field trial was started just over two months ago to compare the formicidal value of endrin with that of dieldrin at two levels, 1 lb. and ½ lb. toxicant per acre in ten gallons. The immediate reduction of the ant population was greater, and the reinfestation and build-up of the population has been slower, in the plots treated at the higher levels of both insecticides. As yet no difference has been observed between the two insecticides at either level.

POLLINATION STUDIES

Entomological

The effect of insecticidal spraying, for capsid control, on pollinating insects. - An experiment to investigate this is at present being set up in the Old Station.

Distance over which pollen is carried. - The first of a series of surveys of the E.1 plot (which is self-incompatible) at Bunso was made during February-March, in an attempt to determine the amount of cross-pollination at various distances from the source of pollen.

Botanical

Comparison of natural setting and pollination. - This experiment continued during the quarter, and is due to finish at the end of May.

Setting rates when cacao flowers are pollinated at various intervals after opening. - A second series of hand-pollinations has been started to compare setting rates at the beginning of the flowering season with the figures already obtained for the end of the season.

ENTOMOLOGICAL ASPECT OF PERSONNEL HEALTH

Transmission of Filaria' parasites by Culicoides Sp.

Breeding sites of Culicoides. - The principal breeding sites of the common species of Culicoides at Tafo have not yet been found, although a number of possibilities have been eliminated.

Activity of Culicoides. - A series of collections of biting female Culicoides was made between December 1956 and February 1957 in an attempt to correlate the numbers biting with climatic factors. Two 'fly-boys' were employed, who collected at two sites on the golf-course, one near the edge of the bush and one in the open, near the Club-House. Collections were made from 06.30 - 07.30 hours and 16.30 - 17.30 hours each day. Temperature, light-intensity and humidity were measured at the start of each collection. The results indicate that the maximum aerial biting populations can be expected with temperature between 75° and 80°F, a relative humidity of over 80%, and light-intensity of 25 - 50 (Weston exposure meter scale).

The mean number of flies per hour caught in the mornings was only 13.6, against 31.43 for the evening collections. Temperature was probably the limiting factor here, as in all the morning collections it was below 75°F, while the humidity was always high, and the light intensities covered the whole range.

BOTANY DIVISION

PLANT BREEDING AND SELECTION

Analysis of the yield date for 1956-7 is proceeding. Heavy crops were obtained. Among the Trinidad Introductions the Upper Amazon cacaos, of which the yield has been declining in recent years, have shown recovery, and the Introductions as a whole have given their heaviest crop yet. There was a marked increase in all trials, largely to be expected from their increasing age. The crop of 31,800 pods from the 1st Clonal Trial, area 4.41 acres, deserves mention. This follows on crops of 21,700 and 23,600 pods in the two previous years. The trial was planted in 1947, and

consists of large-podded types with Trinitario ancestry, (Gold Coast Hybrids), collected from farms by Posnette. The 8th Progeny Trial, area 1.9 acres, planted in 1952, yielded 5880 pods, and the 9th Progeny Trial, area 4.14 acres, planted 1954, yielded 2340 pods.

Among the Upper Amazon types T76 gave an average of 61 pods per stand during the season; T12 gave 56 pods per stand and T60 55 pods. In past seasons these types have given average pod-weights of wet cocoa as follows:- T76 107 gm., T12 91.5 gm., T60 91.9 gm. Recent pod-weight data are not available, as the pods have been distributed as seed.

In the 1st Clonal Trial ACU 85 and A46 have given yields estimated at just over 1,000 lb. per acre dry cocoa. ACU 85 is a type with a relatively low incidence of pod diseases (See quarterly report No. 43).

In the 8th Progeny Trial it is difficult to obtain a precise estimate of the relative performances of the selections, as many are present only as single plots and fertility varies widely over the area. However, the highest estimates of crop from single 36-tree plots are 850 lb. dry cocoa per acre for an Upper Amazon x Amelonado cross, 745 lb. for an Upper Amazon x Gold Coast Hybrid cross, and 700 lb. for an Upper Amazon x Upper Amazon cross. These plots are undoubtedly on rather more fertile ground than most of the trial; for example the Upper Amazon x Upper Amazon cross is also in three other plots, and the average crop for the four plots is 570 lb. per acre.

In the 9th Progeny Trial one selection, a cross between an Upper Amazon type and a Gold Coast Hybrid, has given an estimated yield, based on five 36-tree plots, of 107 lb. per acre in its third year from seed. Again fertility varies widely, and in the best of these five plots the estimated yield was 360 lb.

An examination of the data for 1955-56 for the 2nd Progeny Trial has shown that there are considerable differences in the proportions of pods borne on the trunk on the branches in different selections. High-yielding types with a high proportion of the pods on the trunk include S.45 and U.6

Studies of the season of cropping of the selections in the Clonal Trials and the Introductions Area have been commenced. Differences have been noted. However, the 2nd Clonal Trial attained its peak production almost two months after the 1st Clonal Trial; these two trials consist of very similar

selections and are a quarter of a mile apart. It therefore seems likely that any differences between selections in season of cropping will only be tendencies superimposed on the effects of other controlling factors, which have not been identified.

Studies are being commenced to determine to what extent the quantity of dry cocoa obtained from a given quantity of wet cocoa varies from selection to selection, and to determine the extent to which the degree of variability in bean size differs between selections.

One of the more important trees in the Introductions Area, from which cuttings have been distributed to the Departments of Agriculture in Ghana and Nigeria for potential use for hybrid seed production, has been lost to swollen shoot. It is feared that the cuttings may also be infected, and a warning has been sent out.

Preparations are going ahead for the planting of four further Series II variety trials in Ghana, three Series I and three Series II trials in Western Nigeria, and one of each Series in Eastern Nigeria. The Series I trials compare various Upper Amazon types, and the Series II trials various new crosses as in the 8th and 9th Progeny Trials at WACRI. These trials will allow the selections to be assessed under a range of soil and climatic conditions.

The new Series II trials are being planted in nine replications with 16-tree plots, instead of the four replications and 36-tree plots used before.

VEGETATIVE PROPAGATION

Fertiliser on cuttings

This experiment (Quarterly Report No. 44) is now in its fourth month and as yet there has been no observable response to either P,K or Mg. The first N application was given at the end of the hardening period (i.e. after 1½ months) at the rate of 1.5 gm. urea in 50 ml. of distilled water per basket. This amount proved too great as three days later many of the young shoots and leaves had wilted. Although the majority of these cuttings survived, they have not recovered entirely from the treatment and remain smaller than those in the other treatments. It is possible that biuret in the urea solution produced these toxic effects but this is rather unlikely since the urea used was from a freshly opened bottle and the solution was freshly prepared. This experiment will be repeated using lower concentrations of urea.

Light intensity and cutting growth

It was found in the above experiment that the time at which the dormant bud sprouted was affected by the lighting conditions. There were four replicate sets of treatments each containing 140 cuttings; two replicates were placed under approximately 25 per cent light and two under 10 per cent light. Sixty five per cent of those in 10 per cent light had sprouted after a fortnight whilst only 39 per cent of the other group had shown signs of growth. However after a month the same percentage had sprouted in both cases, and after six weeks those in the higher light intensity were growing more rapidly and had overhauled those in the low light conditions. Growth was measured in terms of shoot length and the number of leaves above half an inch in length. The original pair of leaves in the low light intensity remained dark green whereas those in the higher light intensity frequently turned yellow. This probably meant that the 'low light' cuttings were photosynthesising more effectively than the others and may account for the earlier sprouting of the dormant bud.

All the replicates were placed under 25 per cent light six weeks after setting, and by the end of 14 weeks the '10 per cent light' cuttings had almost reached the size of those which had been in 25 per cent light continuously. The percentage that rooted was not affected by the lighting conditions.

It seems possible from these results that the best growth of cuttings will be obtained by starting them in 10 per cent light and then transferring them to 25 per cent light after two to three weeks. This remains to be demonstrated in a direct experiment.

Single versus double leaf cuttings

A simple experiment is in progress to compare the performances of single leaf and double leaf cuttings under polythene sheet. A considerably smaller proportion of the single leaf cuttings have rooted (only 62 per cent as against 92 per cent) and it appears that the growth of the new shoot is also slower than in the two leaf cuttings. This same result has of course already been obtained using propagating bins (see for example Evans, ICTA Report 1945-51).

PHYSIOLOGY OF NUTRITION, GROWTH AND FRUITING

Investigation of cherelle wilt

The results of these experiments over the quarter confirm the previous suggestion that the final yield of cocoa is

not affected by additional pollination, removal of cherelles, etc. (Quarterly Report No. 44).

Uptake of radioactive phosphate ($P^{32}$)

This experiment is continuing satisfactorily. The trunk and main branches of the trees together contain a considerable proportion of the radioactivity found in the trees after a 10-day uptake period. Furthermore the distribution of this activity in the trunk is not always uniform, frequently being more concentrated on one side than the other. This presumably is a result of variation in the absorbing capacity of the roots round the trunk, but whatever the cause it has necessitated care in the choice of a suitable trunk sampling technique. No attempt to record the amount of activity in the roots of the trees has, so far, been made.

Nutrient uptake by cacao in water culture

A culture solution has been found which promotes vigorous growth of the seedlings. It has been chosen as a result of a comparison of nutrient solutions employed by other workers, and resembles Hewitt's Long Ashton Solution (E.J. Hewitt, "Sand and Water Culture Methods", 1952). Modifications of this solution will be tried when more extensive facilities become available.

The composition of the culture solution is as follows: 0.004M.$Ca(NO_3)_2$; 0.001M.$NaH_2PO_4$ ; 0.0015M.$MgSO_4$ ; 0.003M.$KNO_3$ ; 0.01 m.eq./l. Fe as EDTA complex (i.e. chelated iron) ; 0.2 m.eq./l. Mn ; 0.002 m.eq./l. Cu ; 0.002 m.eq./l. Zn ; 0.033 m.mol/l.B and 0.0002 m.mol./l. Mo.

The seedlings are aerated twice daily, at 7 a.m. and 2 p.m., for a quarter of an hour; this seems to be adequate although for more quantitative work on nutrient uptake more frequent aeration will be used.

Although the temperature of the culture solution varied diurnally between approximately 25° - 32°C no deleterious effects on the plant have been observed.

Three 6-month old plants have been successfully 'transplanted' from pots into water culture. The soil was washed away from their roots with a jet of water. This technique is being further investigated as, if it is always successful, it will provide a short cut to the setting up of larger plants in water culture.

## CHEMISTRY DIVISION

### SOIL FERTILITY

#### Effect of major nutrients on cacao

The following observations have been made on the $2^3$ NPK trials on Upper Amazons at Asokore, Jumapo, Anyinam and Bunso. It has become apparent at the first three centres that the placement of fertiliser in a circle of two ft. radius around the trees in 1954 and 1955 resulted in damage to both trees and soil. Because of this and the difficulties of yield recording, these trials are not being continued. At Bunso there is no evidence of fertiliser damage and the trial is being continued for at least another harvest year. Fertilisers were broadcast over the whole plot areas in 1956 and this practice will be continued. The just-significant response to phosphorus shown at Bunso in the 1955-56 harvest year did not repeat itself in the 1956-57 season.

As soon as the rains start, fertiliser treatments will be applied at the new experimental site at Apedwa (Department of Agriculture Plot 1080 - see WACRI Quarterly Report No. 43). It may be mentioned that the evidence obtained so far indicates that yield data cannot be expected to furnish reliable information on responses to fertiliser application until young cacao has been in bearing at least two, or even three, seasons.

It has been decided not to attempt the $2^3$ NPMg experiment at Asiakwa (Plot 1050 - see WACRI Quarterly Report No. 43) because the area of cacao is too small to allow an adequate degree of replication of treatments.

The Department of Agriculture has completed the yield recording of the 1956-57 harvests at the farms selected for future manurial trials. The Department of Agriculture has also prepared spot plans of the farms and six have been selected to receive fertiliser application in April/May this year. The experimental sites are at: Antoakron, Brofoyedru, Obuasi, Domiabra, Mampong and Juaso. A simple design, namely 2 x 2 (N,P) and (K, Magnesian limestone), is to be used at all sites and the treatments will be replicated eight times at each site if possible. Fertilisers are to be broadcast over the plots (1600 sq.ft.) at the following rates:

N - 100 lb. N/acre/annum (Urea - 46% N)

P - 75 lb. $P_2O_5$/acre/annum (Triple superphosphate - 40% $P_2O_5$)

K - 50 lb. $K_2O$/acre/annum (Potassium sulphate - 48% $K_2O$)

Mg (Ca) - Magnesian limestone at the rate of 5 cwt./acre/annum.

With the exception of the nitrogen application, which will be split - 50 lb./acre in April/May and 50 lb./acre in September, all the other applications will be made in April/May.

Investigation of factors limiting growth in the early life of cacao seedlings

Owing to the fact that shade removal on half the experiment caused severe mechanical damage, the investigation is being discontinued.

Coppiced cacao

The coppiced cacao plots, S.3. (Block G), were handed over to the Plantations Manager in January.

Soil fertility investigation on clear-felled land

Ninety eight per cent of the cacao seedlings have successfully survived the dry season.

The degradation of exposed forest-soil

A small area of land in Block H (WACRI soil series) which carried a heavy cover of bush has been cleared. According to Station records, this land has not supported cacao, or any other crop, for at least 20 years. It is the nearest approach to undisturbed soil that it is possible to find at WACRI.

Three treatments, replicated eight times, have been superimposed on the soil: complete exposure, half shade (artificial), and full shade (artificial). Changes taking place in the soil will be followed on samples taken at monthly intervals.

Pot experiment on seedlings (Upper Amazon)

The results from the experiment on 'the comparison of nitrogen supplied in three forms' (Quarterly Report No. 43) are of sufficient interest to warrant their inclusion in this report. The soil used (6 Kg. dry soil per pot) was the sandy humus-rich 0-5" horizon from the Jumapo soil series. Soil applications of phosphorus and potassium as $KH_2PO_4$ were made in solution at the rate of 0.18 gm. P and 0.23 gm. K per pot at the beginning of the experiment when the initial mean height of seedlings was 36.7 cm. Nitrogen was applied in solution to the soil at the beginning of each month at two rates namely 0.5 gm.

and 1.0 gm.N per pot, there being four applications in all. The effects of nitrogen in the form of urea, ammonium sulphate and sodium nitrate were compared. All pots were watered liberally, but through drainage was avoided. The seedlings, originally grown in a plant barn, were shaded with wooden slats so that they received 66 per cent of the incident light for the duration of the experiment.

The following results were obtained:

| Treatment | | | Mean height-increment of seedlings over 4 month period |
|---|---|---|---|
| None | | | 14.8 cm. |
| PK | | | 21.5 cm. |
| N-Urea | (0.5gm.N/month) | PK | 31.1 cm. |
| N-Urea | (1.0gm.N/month) | PK | 26.6 cm. |
| N-$(NH_4)_2SO_4$ | (0.5gm.N/month) | PK | 28.6 cm. |
| N-$(NH_4)_2SO_4$ | (1.0gm.N/month) | PK | 30.0 cm. |
| N-$NaNO_3$ | (0.5gm.N/month) | PK | 18.1 cm. |
| N-$NaNO_3$ | (1.0gm.N/month) | PK | 14.0 cm. |

S.E. of difference of mean height-increment = 5.23

Degrees of freedom for error = 35

It should be mentioned that the high level application of urea visibly retarded the growth of seedlings for the first two months. Sodium nitrate produced marginal leaf scorch at both levels of application and the retardation of growth, as compared with growth in pots receiving the other forms of nitrogen, was apparent after the first month.

Further work on the nutrition of cacao growing in pots under controlled shade is being carried out.

The possibility of using quick growing annual plants as fertility indicators for cacao soils is also being investigated.

COCOA PREPARATION AND QUALITY

Quality assessment of samples prepared from the experiments conducted on the 1956-57 main crop has not been completed but results so far obtained confirm the lack of uniformity in the rate of fermentation in heaps.

Cocoa flavour is developed much more quickly than has previously been admitted and reduction of astringency and bitterness follows rapidly on the death of the bean.

Sufficient evidence is at hand to show that if the temperature of the bean mass rises to 46°C within 24 hours then good quality cocoa can be obtained after only another six hours fermentation. These conditions are usually present at the

surface of a fermenting heap and removal of the surface layer approximately six hours after the death of the beans (i.e. about 30 hours total) gives a product which compares favourably with standard West African Amelonado.

Similar changes are observed at the centre of the fermenting mass but taking place at a much lower rate.

The changes in the polyphenolic bodies which occur at different levels in the fermenting mass are being determined in order to find if there is any relationship between their removal and flavour development.

Studies on cacao enzymes

It was stated in Quarterly Report No. 44 that polygalacturonase activity had so far not been found in cacao beans. Further tests have shown that very weak activity is present in acetone-powders of both unfermented and germinated beans. Activity was still detectable in beans fermented for one day, but not after longer periods of fermentation.

From figures available in the literature it appears that starch is not broken down during fermentation, suggesting that either amylase is absent or that its action is inhibited. Amylase activity has been tested for by determining the amount of reducing sugar liberated from soluble starch. The activities of acetone-powders of fresh and sun-dried unfermented beans, and of beans which had been fermented for various times were compared. An active amylase was found in both fresh and dried unfermented beans. During the first 24 hours of fermentation there appeared to be a slight rise in activity and it then decreased until after four days none was detectable. A crude preparation of cacao starch was not attacked by the bean amylase unless it was first 'solubilized' by boiling. Since many amylase preparations have an extremely weak action on raw starch it is therefore not particularly surprising that the starch in the bean is not attacked during fermentation, even though amylase is present.

Catalase determinations were made on the same series of acetone-powders. This enzyme was less stable to drying and fermentation than the amylase; it had disappeared at the end of two days fermentation.

# I B A D A N  S U B-S T A T I O N

## PATHOLOGY SECTION

### NIGERIAN ISOLATES OF CACAO VIRUS

Since cacao swollen shoot disease was first discovered in Nigeria in 1945, isolates of virus have been collected from many of the scattered outbreaks and their effects on young cacao plants studied under insectary conditions. This work was started by members of the staff of the Nigerian Department of Agriculture and was later continued by workers of W.A.C.R.I., first of all in Ghana and since 1953 also at the Institute's Substation in Nigeria.

Ten of the many isolates which have been collected are considered to be sufficiently distinct from each other to warrant further investigation and they are being used in a series of detailed experiments. The symptoms caused by these isolates have been followed on young plants infected by means of patch grafts and wherever possible by insects. These two methods are also being used to introduce the challenging virus in protection tests involving all possible combinations of the ten isolates.

In carrying out the detailed symptom recording it was found necessary to keep the infected plants under observation for several months, as they usually show a definite sequence of symptom development and quite different isolates of virus may closely resemble each other at an early or late stage of infection. When the plants were flushing it was found necessary to carry out the symptom observations at least twice each week, otherwise the full details of symptom development would be missed and some leaves might never be recorded at all as they are sometimes lost before maturing.

The leaf symptoms found on infected plants are of two types, the transient ones which appear on the young expanding flush leaves, and the permanent symptoms which appear as the leaves develop and persist until leaf fall. The two types of symptom appear to be quite different manifestations of virus activity, as transient symptoms are not necessarily followed by permanent ones, and symptoms may appear on hardened leaves which were apparently normal in their immature condition.

The transient leaf symptoms are caused by an abnormal distribution of the red anthocyanin pigments in the tissues bordering the midrib and principal veins. This 'red vein banding' symptom may be mild and barely discernible, or it may be strikingly obvious, and it is most conveniently seen on cacao of

the Amelonado type, which has normally little pigment in the flush leaves. As the leaves harden the red pigment of both healthy and affected leaves becomes less obvious, as it normally disappears or becomes masked by the appearance of the green chlorophyll pigments. However, the obvious red vein banding symptoms may persist in some leaves, causing an intensification of the green pigment in the tissues along the affected veins. With some virus isolates the red-vein banding symptom extends into the inter-veinal areas and the leaves have a red mottled appearance, affected areas of the leaf later becoming a darker green than usual.

The permanent leaf symptoms appear as the leaves develop and mature and they are caused by an abnormal distribution of the chlorophyll pigments. They vary considerably in severity and take various forms, although the symptoms tend to follow the principal veins, particularly when the plants have been infected for some months. Permanent leaf symptoms usually occur outside the areas which were affected by the red vein banding symptom, or on the margins of these areas, and they usually undergo some modification as the leaves harden.

Of the ten isolates of cacao virus which have been kept under detailed observation, the one from Asalu and adjacent villages in Abeokuta Province has never been experimentally transmitted by mealybugs or any other insects. Furthermore, when young plants are graft-infected with this virus they first show severe necrotic symptoms and then recover. These symptoms are quite different from those caused by other cacao virus isolates and for this and other reasons the new name of cacao necrosis virus is proposed for viruses of this type.

The remaining nine isolates differ considerably amongst themselves, although they are all readily transmitted by at least one species of mealybug. The virus from the Ibadan Native Administration farm gives swellings but never gives permanent leaf symptoms, while the isolates from Alaparun and Balogun give different types of leaf symptoms and no swellings. The other isolates which have been studied all give leaf symptoms and swellings, nevertheless, they may be readily distinguished from each other by the type and severity of the symptoms they produce.

It has frequently been noted in the detailed symptom recording work and in the routine transmissions, that plants which are infected by insects from an apparently uniform source of virus do not always show the same symptoms, and some of them show

particularly mild or severe symptoms compared with those shown by the majority. Further back-tests indicate that in some instances the effect is due to certain plants tolerating infection with virus which normally has severe effects, although the usual explanation seems to be that source plants are commonly infected with mild and severe forms of virus which become segregated during the transmission work. A further possibility is that plants vary in their reaction to infection depending upon the amount of virus introduced into their tissues by feeding mealybugs. This possibility is being further investigated in a series of experiments designed to determine the effect of infestation rate on the rapidity with which symptoms appear and on their severity. Additional evidence for the existence of virus strains has been obtained on back-testing infected trees, and it has been found that adjacent trees in outbreaks may be infected with viruses which differ markedly in the symptoms they cause and their effects on growth.

The limited number of protection tests which have been carried out indicate that at least some of the mealybug transmitted isolates of Nigerian cacao virus are immunologically distinct, and by analogy with the more extensively studied viruses from Ghana it seems likely that further work will also reveal that differences in host range and vector specificity occur amongst the Nigerian isolates. This raises the question of their relationships At the present time, however, it is considered that there is insufficient evidence to justify a detailed classification or subdivision of the cacao viruses occurring in Nigeria. These will still be referred to as strains of cacao swollen shoot virus, even though it is appreciated that there are various degrees of relationship and that the name is obviously unsatisfactory for some of the isolates which consistently fail to give swellings.

## ENTOMOLOGY SECTION

### CAPSID STUDIES

#### Chemical Control of Capsids (Joint Investigation by W.A.C.R.I. and The Department of Agriculture, Western Region)

The last applications of gamma BHC for the capsid spraying season August, 1956 to February, 1957, were given to all treated plots between 11th and 22nd February. Capsid counts, assessments of canopy damage and regeneration, and harvesting of ripe pods are being continued at monthly intervals.

The decline in capsids counted on the untreated plots between September and December, 1956 (See Quarterly Report No. 44) was followed in January by a rise to a new and higher peak, and a subsequent rapid decline in February and early March. Records of capsid counts obtained in previous years by the Entomology Section of the Federal Nigerian Department of Agricultural Research also show a similar increase in numbers of capsids at about this time and indicate that this may be followed by a period of relatively high capsid numbers lasting until March in some years.

A probable explanation of the fluctuations in numbers of capsids recorded is that in November and December, when there are fewer green pods on the trees, the majority of the capsids are to be found on the branch system of the canopy, much of which is inaccessible to the operators. With the onset of harmattan conditions the upper portions of the canopy are subjected to some desiccation and probably become less suitable as feeding sites for capsids. If for this reason capsids move down to the lower storey of the cacao where they can be reached by the operators an increase in the numbers recorded would occur at this time of the year.

Whether the increase in capsid counts in January is due to a true increase in capsid populations, or to a movement of capsids as suggested above, it may be of importance in considering the possibility of reinfestation of treated farms at this time of the year, or in determining the duration of the capsid spraying season.

An even greater increase in the relative numbers of capsids counted between December and January was noted in the plots to which BHC dust was applied, though on these the peak population was only 18 per cent of that observed on the untreated plots. The subsequent decline was slower on the dusted plots (see table on page 31).

The doubt cast upon the value of capsid counts taken from the lower storey of the cacao as estimates of the true capsid population are justified if capsids vary in their accessibility to the operators, but the factors causing this variation, e.g. presence or absence of green pods on the trunks, and the effects of climatic conditions, should cause comparable variations in counts from all plots irrespective of the insecticidal treatment applied, and these should therefore give a reasonably accurate indication of the effects of such treatments, provided that in all treatments the cover extends to the canopy.

The failure of the plots receiving regular overall applications of BHC sprays to show a rise in counts in January (see table) may be attributed to the very low residual capsid populations remaining after five months of treatment, and to the continuation of effective control measures. On the basis of these counts it appears that four-weekly applications of 4 oz. gamma BHC per acre using pneumatic knapsack spraying machines fitted with a nozzle producing a very fine mist spray (Treatment D) are as effective as regular spraying with BHC from motor-driven mist-blowing machines, despite the fact that the former machines do not project the insecticide into the highest parts of the canopy.

Assessments of capsid damage on the branch system confirm that good control is obtained by this method, though not so rapidly as with an equivalent quantity of insecticide applied with a motor driven machine (Treatment B). The capsids in the higher portions of the canopy thus appear to be killed despite the limited throw of the pneumatic machines and this effect may be attributable to the upward drift of small droplets of insecticidal solution and/or the fumigant action of BHC, though the latter is likely to be quite small at the rates applied.

Spot treatments with knapsack machines given to trees on which recent damage is seen, and to their contacts, at each four-weekly inspection (TreatmentE) gave slightly less control of both capsid numbers and recent damage than did repeated four-weekly overall spraying but the control was better than that obtained with dusts and the damage encountered was only four per cent of that observed in the untreated plots.

Treatment

A. 2 oz. gamma-BHC/acre low volume every 4 weeks from Aug. to Feb. inclusive.

B. 4 oz. gamma-BHC/acre low volume every 4 weeks from Aug. to Feb. inclusive.

C. 4 oz. gamma-BHC/acre low volume every 8 weeks from Aug. to Feb. inclusive.

D. 4 oz. gamma-BHC/acre high volume every 4 weeks from Aug. to Feb. inclusive.

E. 4 oz. gamma-BHC/acre low volume in Aug. and Sept. followed by high volume applications where damage occurs.

F. 4 oz. gamma-BHC/acre hand dusting in Aug. and Sept. followed by hand-dusting applications where damage occurs.

G. No treatment

## CAPSID COUNTS & DAMAGE ASSESSMENTS

| Treatment | A | | B | | C | | D | | E | | F | | G | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Date | X | Y | X | Y | X | Y | X | Y | X | Y | X | Y | X | Y |
| 8.Oct. - 2.Nov. | 14 | 18 | 18 | 12 | 10 | 33 | 16 | 39 | 7 | 43 | 29 | 71 | 402 | 402 |
| 5.Nov. - 30.Nov. | 8 | 14 | 5 | 10 | 5 | 47 | 0 | 15 | 1 | 26 | 27 | 53 | 350 | 661 |
| 3.Dec. - 28.Dec. | 6 | 14 | 5 | 8 | 10 | 23 | 5 | 11 | 17 | 38 | 39 | 100 | 301 | 823 |
| 31.Dec. - 25.Jan. | 3 | 1 | 2 | 3 | 7 | 11 | 3 | 4 | 15 | 8 | 75 | 68 | 424 | 898 |
| 28.Jan. - 22.Feb. | 0 | 4 | 0 | 0 | 3 | 11 | 3 | 0 | 19 | 28 | 46 | 107 | 244 | 743 |
| 25.Feb. - 22.Mar. | 3 | - | 1 | - | 2 | - | 3 | - | 3 | - | 36 | - | 81 | - |
| Total | 34 | 51 | 31 | 33 | 37 | 125 | 30 | 69 | 62 | 143 | 252 | 399 | 1802 | 3527 |
| Total as % G | 1.9 | 1.4 | 1.7 | 0.9 | 2.1 | 3.5 | 1.7 | 2.0 | 3.4 | 4.1 | 14.0 | 11.3 | 100.0 | 100.0 |

For Treatments A to G see page 30.

X - Total capsids counted on 100 trees in each of nine plots.
Capsid counts are taken in the first fortnight of the month.

Y - Total capsid damage assessments from 100 trees in each of nine plots.
Assessments are made in the second fortnight of each month and those for 11th - 22nd March have not yet been received.